Female: Total body length of adult, 10.5 to 11.1 mm. Frontal appendage absent. First antennae about as long as clasping antennae. Clasping antennae flattened, pointed at apex, uniformly rounded on margins. Eyes stalked, with greatest diameter less than 0.5 mm. Ovisac one-half as long as abdomen with cercopods excluded. Ovisac gourd-shaped, not uniformly tapering, with apex turned abruptly toward the abdomen. Cercopods uniformly tapering, with setae of approximately one-fourth total length of cercopod.

*Remarks.*—This species may be distinguished from other North American phyllopods by the shape and structure of the bilaminate male frontal appendage and by the sickle-shaped appearance of the clasping antennae.

*Types.*—I collected the types of this new species in temporary pools in the granite rock on the summit of Stone Mountain, DeKalb County, Ga., within 100 yards of the airway beacon, June 9, 1939. They have been deposited in the United States National Museum: Holotype male, no. 79294; allotype female, no. 79295.

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# ZOOLOGY.—Cercaria pricei, *a new trematode, with remarks on the specific characters of the "Prima" group of Xiphidiocercariae.*[1]

Miriam Rothschild, London, England. (Communicated by E. W. Price.)

It is not an unusual phenomenon to discover several very closely related species of larval trematodes parasitizing the same host. *Cercaria pricei* n. sp., described in this paper, is the third species of the "Prima" subgroup of Cercariae ornatae (Lühe, 1909) to be found in the snail *Pseudosuccinea columella* Say. Although this type of cercaria was originally recorded from Europe, almost all the important experimental work on their life histories has been carried out in brilliant fashion by Krull (1931, 1933) and other workers in the United States.

The individual author's spelling of host names is used herein. Furthermore the generic and specific names of the adult fluke used by the author in his description of its cercaria and life history are retained to avoid confusion.

I should like to express my gratitude to Dr. E. W. Price for his kindness in affording me every facility for work during my unexpected visit to Washington at the outbreak of the European war, to the Spen-

[1] Received June 3, 1940.

cer Lens Company for lending me superlative microscopical apparatus, and to Dr. J. P. E. Morrison and Countess Mary Roberti for assisting in the collection of specimens.

## CHARACTERS OF THE "PRIMA" SUBGROUP OF CERCARIAE ORNATAE

Sewell (1922) recognized that certain species of "Ornatae" Xiphidiocercariae formed a compact natural group of which *Cercaria prima* Sinitzin, 1905, was selected as the "type." Sewell's definition can be emended on several unimportant points. He regarded only the stem of the Y-shaped excretory bladder as the bladder proper and described the crura as dilatations of the excretory tubes. The subsequent development of the bladder in the metacercaria shows that this is erroneous. Two species with six pairs of penetration glands have also been discovered since 1922.

McMullen (1937) has shown that the presence or absence of a tail fin-fold may not be a character of great importance when forming a natural classification within a large group like the Plagiorchioidea. With this opinion I am in entire agreement. In the matter of tail structure and modification or loss of fins there is repeated evidence of parallel evolution in distantly related genera within one superfamily.[2] McMullen writes:

> In the cercariae of the frog lung flukes and related forms a similar situation arises. The cercariae of these trematodes . . . all have a fin-fold on the tail except the cercaria of *Haplometra cylindracea*. Here the absence of the fin-fold would, in the present classification, eliminate this form from the Ornatae group of Xiphidiocercariae and thus separate it from closely related forms. It seems probable, therefore, that the fin-fold of the tail and other such larval modifications are of little more than specific value in the Xiphidiocercariae.

However, the adult forms of "Prima" cercariae have all proved to be frog lung flukes of the subfamily Haematoloecinae Freitas and Lent, 1939 (=Pneumonoecesinae Mehra, 1937). *Haplometra cylindracea* Zeder is not in my opinion closely related to this subfamily, and in the opinion of Mehra (1937) it pertains to another family altogether. The absence of a tail membrane in this cercaria is therefore not considered to have any special bearing on the subgroup now under consideration, and the presence of a "Prima" type of fin-fold is for the present retained as a diagnostic character.

[2] Another type of parallel evolution to be found in the tail structure of cercariae is worthy of note. This may be typified by the giant tails found in unrelated cercariae which are swallowed as free swimming organisms by fish, for example, *Petasiger nitidus* Linton, 1928 (Echinostomidae) and *Proterometra macrostoma* (Faust, 1918) (Azygiidae).

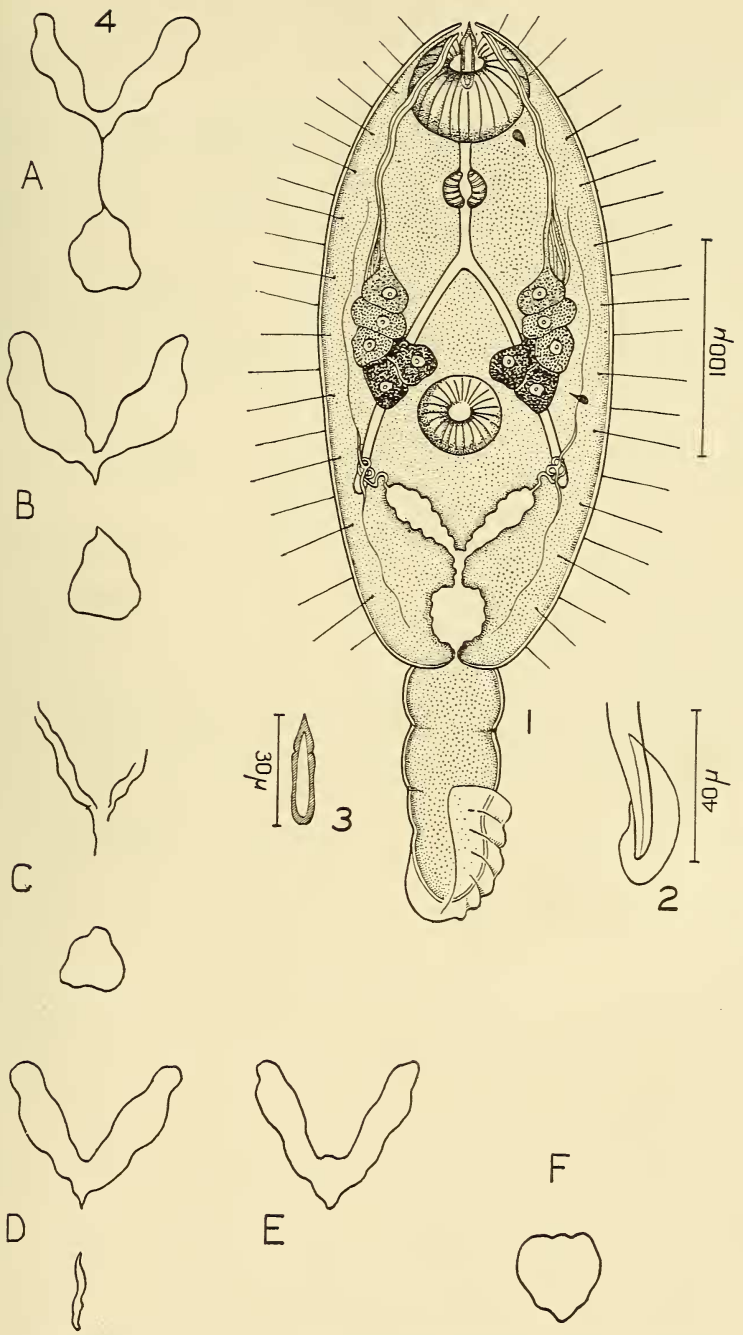


Fig. 1.—Diagram of *Cercaria pricei* from ventral aspect with tail contracted (penetration glands shown slightly larger than in reality. Fig. 2.—Fin-fold under pressure of a coverslip. Fig. 3.—Stylet. Fig. 4.—A–F, Diagrams showing appearance of excretory bladder during different stages of contraction.

### THE "PRIMA" SUBGROUP SEWELL, 1922 (EMENDED)

(1) Distome Xiphidiocercariae of medium size in which the acetabulum is situated behind the middle of the body length.

(2) The tail is shorter than the body and is furnished with a dorsoventral fin-fold in its distal portion; the ventral portion of the fin extends farther forward than the dorsal portion.

(3) The alimentary canal possesses a prepharynx and a pharynx, and the intestinal caeca reach back to a point between the margin of the acetabulum and the posterior end of the body.

(4) Four to six pairs of penetration gland cells are present.

(5) The excretory bladder is Y-shaped and does not extend beyond the lateral margins of the ventral sucker. The main excretory tubes enter the bladder at the extremity of the arms of the Y. They divide into anterolateral and posterolateral branches at the level of the ventral sucker. The excretory pattern is $2[(1+1+1)+(1+1+1)]=12$ or $2[(3+3+3)+(3+3+3)]=36$.

(6) Development occurs in small unbranched sporocysts.

(7) The first intermediate hosts are fresh-water gastropod mollusks, and the second intermediate hosts are arthropods.

Thirteen species may with certainty be included in this group:

*Cercaria prima* Sinitzin, 1905.
*Cercariae indicae* XXIV Sewell, 1922.
*Cercariae indicae* XXVIII Sewell, 1922.
*Cercaria longistyla* McCoy, 1929.
*Cercaria prima* Dubois, 1929 (*nec* Sinitzin, 1905).
Cercaria of *Pneumonoeces medioplexus* (Stafford, 1902) Krull, 1931.
Cercaria of *Pneumobites pariplexus* (Irwin, 1929) Krull, 1931.
*Cercaria prima* Wesenberg-Lund, 1934 (*nec* Sinitzin, 1905, *nec* Dubois, 1929).
Cercaria of *Haematoloechus complexus* (Seely, 1906) Krull, 1933.
Cercaria of *Ostiolum oxyorchis* (Ingles, 1932) Ingles, 1933.
*Cercaria herberi* McMullen, 1938.
*Cercaria merchanti* Rankin, 1939.
*Cercaria pricei* n. sp.

Of these species *C. prima* Wesenberg-Lund was examined from a crushed snail only, a fact that undoubtedly accounts for the undeveloped state of the intestinal caeca. From time to time various species such as *Cercaria pela* Porter, 1938, *C. elemensis* Porter, 1938, and *C. laticauda* Wesenberg-Lund, 1934, have been erroneously assigned to this subgroup. These larvae generally display features that place them in Lühe's Cercariae ornatae but that exclude them from the circumscribed "Prima" subgroup. There are certain other species, such as *Cercaria ornata* Lutta, 1934 (*nec* La Valette, 1855), *Cercaria pratensis* Skwortzoff, 1924, and *Cercaria prima* Ruszkowski, 1925 (*nec* Sinitzin, 1905), whose exact systematic position must remain doubtful until more adequate descriptions are available.

TABLE 1.—DATA ON 13 SPECIES OF CERCARIA IN THE "PRIMA" GROUP

| Species of Cercaria | First intermediate hosts | Second intermediate hosts | Number of penetration gland cells (pairs) | Size of stylet |
|---|---|---|---|---|
| *Cercaria prima* Sinitzin, 1905 | *Aplexa hypnorum*, *Planorbis vortex* var. *compressa*. | Larvae of *Corethra* and *Ilybius* (Ephemeridae). | 5 | 25$\mu$ in length. |
| *Cercariae indicae* XXIV Sewell, 1922 | *Limnaea succinea*. | Unknown. | 4 | ? |
| *Cercariae indicae* XVIII Sewell, 1922 | *Limnaea acuminata*. | Unknown. | 4 | 0.028 mm. |
| *Cercaria longistyla* McCoy, 1929 | *Physa integra*, *P. anatina*. | Dragonfly larva, small water insects. | 5 | 32 by 4$\mu$. |
| *Cercaria prima* Dubois, 1929 (*nec* Sinitzin, 1905) | *Aplexa hypnorum*, *Lymnaea palustris*. | *Asellus aquaticus*. | 4 | 29–33$\mu$ long, 4.5–6$\mu$ wide. |
| Cercaria of *Pneumonoeces medioplexus* (Stafford, 1902) | *Planorbula armigera* (Say). | *Sympetrum obtrusum* (Hagen), *S. rubicundulum* (Say). | 6 (probably) | 17.5$\mu$ by 2.36$\mu$. |
| Cercaria of *Pneumobites parviplexus* (Irwin, 1929) | *Gyraulus parvus* (Say). | *Sympetrum obtrusum* (Hagen), *S. rubicundulum* (Say). | 5 (probably) | 19.9$\mu$ in length. |
| *Cercaria prima* Wesenberg-Lund, 1934 (*nec* Sinitzin, 1905; *nec* Dubois, 1929) | *Planorbis albus*. | Unknown. | 4 | No measurements of fully developed cercaria. |
| *Cercaria* of *Haematoloechus complexus* (Seely, 1906) | *Pseudosuccinea columella* Say. | *Sympetrum vicinum*, *Pachydiplax longipennis*, *Holotania* (*Libellula*) *incesta*, *Chromagrion conditum*, *Enallagma divagans*, *Lestes vigilax*, *Tetragoneuria cynosura* Say, *Argia* sp. | 5 | 30$\mu$ average length, 5$\mu$ average width. |
| *Cercaria* of *Ostiolum oxyorchis* (Ingles, 1932) | *Planorbis* (*Gyraulus*) *parvus* Say, *Planorbis* (*G.*) *vermicularis* Gould | *Plathemis lydia* (Drury), *Sympetrum illotum* (Hagen). | ? | 22$\mu$ in length. |
| *Cercaria herberi* McMullen, 1938 | *Physella magnalacustris* (Walker) | Mosquito larvae, Dragonfly naiads. | 6 | 0.034 mm (length). |
| *Cercaria merchanti* Rankin, 1939 | *Pseudosuccinea columella* Say. | Dragonfly nymphs, Damselfly nymphs. | 5 | 0.04 by 0.004 mm. |
| *Cercaria pricei* n. sp. | *Pseudosuccinea columella* Say. | Unknown. | 5 | 30–34$\mu$ by 4.2–5.1$\mu$ |

SPECIFIC CHARACTERS OF THE "PRIMA" SUBGROUP

Judged from the descriptions by such excellent observers as Krull and Sewell it is only a little less difficult to distinguish between these larvae than certain heterophyid, notocotylid, and microphallid cercariae. Up to a point the same difficulties are encountered as those indicated for Opisthorchioidea cercariae (Rothschild, 1938). Measurements of soft parts can only be regarded as supplementary data, although in some cases the discrepancy in size is so great that it can not be due to difference in the technique adopted by individual observers. Measurement of the stylet is, however, of much importance. As in other groups, the relative degree of development and transparency of certain organs, such as sensory setae, cuticular spines, intestinal caeca, reproductive anlage, etc., are specific differences that do not lend themselves well to written descriptions. Perhaps one of the most tantalizing characters of this type is the relative thickness or toughness of the cuticle. The cercaria of *Pneumobites parviplexus*, for example, fragments after a few seconds under a coverslip, whereas *C. pricei* n. sp. remains intact for many hours. This is no doubt an extreme case, but in comparing cercariae almost every worker comes across subtle differences of this type that, although very obvious, can not be accurately described and at times even defy analysis.

The number and arrangement of penetration glands can vary specifically, but as the range is small this may not be very helpful (Table 1). The ducts apparently can open at the base or the tip of the stylet (*C. indicae* XXVIII, *C. indicae* XXIV). The shape and color of the parthenitae, together with the number of cercariae maturing simultaneously within each sporocyst, also vary specifically, but the age of an individual infection and the temperature of the water (Rothschild, 1935) appear to exert some influence upon these characters. Two different excretory patterns are met with. In one the full complement of flame cells found in the adult fluke is already developed, and in the other each group is represented by one flame cell only. No more than three patterns have been completely worked out. The distribution of sensory setae may be of much importance, but apparently in many cases these structures are not visible to the ordinary observer. Sinitzin undoubtedly possessed superior eyesight and described them in wonderful detail for nearly all his cercariae. The accuracy of his observations is verified from time to time when a species is found in which they are more obvious than in others.

TABLE 2.—BEHAVIOR OF CERCARIA

| Species of Cercaria | Time of emergence from snail host | Duration of free swimming life | Tropisms | Other characteristics |
|---|---|---|---|---|
| Cercaria of *Ostiolum oxyorchis* (Ingles) | Afternoon and night. | About 24 hours. | No reaction to light or darkness. | Swim at all levels of water. |
| Cercaria of *Haematoloechus complexus* (Seely) | Throughout day. | ? | ? | |
| Cercaria of *Pneumobites parviplexus* (Irwin) | During afternoon. | ? | No heliotropic response. | Uniformly distributed throughout water except in cool of morning, when swims sluggishly near bottom of container. |
| Cercaria of *Pneumonoeces medioplexus* (Stafford) | Chiefly during night. | ? | Do. | Do. |
| *Cercaria herberi* McMullen | ? | ? | ? | Good swimmer. |
| *Cercaria merchanti* Rankin | ? | ? | Positively phototropic; negatively geotropic; some response to shadow. | Rapid and constant swimmer. |
| *Cercaria indicae* XXIV Sewell | ? | ? | ? | Somewhat feeble swimmer. |
| *Cercaria pricei* n. sp. | Throughout day. | About 9 hours (at room temperature in tap water). | No response to light or shadow. Occasionally swarm around objects in water. | Swims at all levels of water. Frequently dies fixed and flattened against sides of container. |

Specific descriptions of "Prima" cercariae can be based on the following characteristics:

(1) Size:
  (a) Relative length of body and tail.
  (b) Relative size and position of suckers, pharynx,[3] prepharynx, and esophagus.
(2) Shape and dimensions of stylet (see Table 1).
(3) Precise extent and shape of caudal fin-fold.
(4) Behavior (see Table 2):
  (a) Time of emergence from the snail host.
  (b) Duration of free swimming life.[4]
  (c) Tropisms.
  (d) Choice of second intermediate host (including negative data).
(5) Cyst:
  (a) Shape (see Dubois, 1929, p. 56).
  (b) Size.
  (c) Location.

Supplementary characters:

(6) Excretory pattern.
(7) Number of penetration gland cells.
(8) Distribution of sensory setae.
(9) Presence of sensory papillae.
(10) Sporocysts:
  (a) Shape.
  (b) Color.
  (c) Number of cercariae maturing simultaneously within each sporocyst.

It is probable that these characters are valid for differentiating between other subgroups of Cercariae ornatae such as the "Hemilophura" subgroup. These differ essentially from "Prima" cercariae in the possession of an I-shaped excretory bladder, a fin-fold extending along the whole or two-thirds of the ventral side of the tail but not along the dorsal side, and elongated "worm"-shaped sporocysts. Variation in behavior has also been noted. The cercaria of *Macroderoides typicus* emerged "in the mid-morning hours . . . and died within a few hours" (McMullen, 1935), whereas the cercariae of *Haplometrana utahensis*, "are shed throughout the day and night with the greatest numbers appearing towards the evening . . . and lived as long as 40 hours" (Olsen, 1937).

[3] The conspicuously large pharynx of the cercaria of *Ostiolum oxyorchis* is also a feature of the adult fluke.

[4] The term "duration of free swimming life" I understand to mean the period during which the cercaria is capable of swimming in the water after natural emission from the snail host (Rothschild, 1938), and not the period during which the cercaria manifests movement or "signs of life." In most instances the latter character does not lend itself so well to accurate and clear cut comparison (Dubois, 1929), although it is useful as supplementary data (Wheeler, 1939).

**Cercaria pricei,**[5] n. sp. Figs. 1–4

*Description.*—Xiphidiocercaria of the "Prima" type, with the characters of the group. Measurements in microns (under light pressure of coverslip): Body length 375 to 257, mean 327; width 149 to 107, mean 135. Tail length 232 to 166, mean 200; width 49 to 41, mean 45. Fin 41 long ventrally, 22 dorsally; maximum width 17. Oral sucker 68 by 68 to 51 by 51, ventral sucker 44 by 51 to 31 by 41. Pharynx 25 by 22, prepharynx length 11.9 to 15.3; esophagus length 25. Stylet 30 to 40 by 4.2 to 5.1. Sporocyst (maximum) 249 by 124.

Body regularly oval in outline. Tail when extended two-thirds length of body, when contracted one-half length of body. Ventral sucker slightly more than half diameter of oral sucker, situated somewhat less than two-thirds of body length from anterior extremity. Esophagus short, barely longer than pharynx. Intestinal caeca well developed. Five pairs of penetration gland cells of which the posterior three pairs are coarsely granular, slightly larger, and dorsal to the two anterior pairs. Ducts of glands arranged in two groups opening near anterior extremity of stylet. Crura of bladder not reaching posterior border of ventral sucker. Cuticle faintly rugose, without spines or sensory tubercles. Two rows of long sensory setae along lateral edges of body, arranged as in *C. prima*. Parthenitae stumpy, sausage-shaped, pale yellow; one to two cercariae maturing simultaneously within each sporocyst.

*Behavior.*—The cercariae emerge throughout the day, the length of free swimming life being nine hours in tap water at room temperature.

No phototropic responses.

*First intermediate host.*—*Pseudosuccinea columella* Say.

*Locality and date of collection.*—Shaw Lily Gardens, Washington, D. C., September-October, 1939.

*Remarks.*—*Cercaria pricei* most closely resembles the Cercaria of *Haematoloechus complexus* described by Krull and *Cercaria merchanti* described by Rankin, both from the same host. It can be separated from the former by its much greater size, number and arrangement of sensory setae, the relatively shorter prepharynx, and greater distance between the fork of the intestine and the ventral sucker. In *C. merchanti* the forks of the Y-shaped bladder extend to the lateral borders of the acetabulum; the long sensory setae are absent but sensory tubercles are present around the oral sucker; the stylet is narrower in comparison with its length; and there are also differences in behavior (see Table 2).

One of the most striking features of *C. pricei* is the periodic contractions of the bladder. First the cavity of the stem is obliterated and then the branches of the Y. This curious phenomenon is not mentioned by either Krull or Rankin, but Ingles (1933) has noted it for the Cercaria of *Ostiolum oxyorchis*, and Miller (1935) and Dubois (1929) record it for "Polyadena" cercariae. Krull's drawing of the bladder of the Cercaria of *H. complexus* does not entirely agree with the description, and in fact the bladder figured for *Cercaria tricystica* Miller, 1935, *C. helvetica* V Dubois, etc., more closely

[5] Named for Dr. E. W. Price, of the U. S. Bureau of Animal Industry, in honor of his many contributions to our Knowledge of the Trematoda.

resembles that of *C. pricei* than several of those figured for "Prima" cercariae!

It has already been mentioned that the ducts of the penetration glands are arranged in bundles. They are so closely approximated that anterior to the esophagus there appear to be only two ducts and two apertures on each side. It sometimes happens that one of the posterior pairs of glands, which are situated dorsally, presents the finely granular appearance characteristic of the anterior ventrally situated pairs (see also Sewell, 1922, p. 222). A large spherical nucleus and prominent nucleolus are conspicuous in each penetration gland cell.

Unlike *C. merchanti*, *C. pricei* does not collect on the lighted side of the vessel and in fact shows no phototactic responses whatsoever. At times it manifests a definite tendency to accumulate near the surface. At other times, however, the cerceriae remain distributed at all levels of the water or segregate in the lower levels. It seems probable that the nature of their geotropic response is correlated with temperature changes as suggested by Krull (1931) for cercariae of *P. medioplexus* and *P. parviplexus*. *C. pricei* swims continuously from the time of emergence, with occasional momentary pauses when the body is suddenly extended horizontally. There is also a slight tendency to swarm around small objects in the water, particularly the snail host, but this again seems to depend on certain unknown factors, as it is manifested on some days and not on others.

One very peculiar habit is typical of this cercaria. A fairly large number were kept in glass tumblers, and while swimming they quite frequently came into contact with the sides of the vessel. They then attached themselves and crawled about on the glass by the usual "leeching" movements. At death they did not drop off and fall to the bottom of the container but became fully extended and remained flattened against the glass like a series of permanent preparations. Water beetles, dragonfly nymphs, and other insect larvae were fished from the same pond and introduced into the jars with the cercariae, but penetration was not observed.

## EFFECT ON THE SNAIL HOST

The effect of trematode parasites on the ultimate size and growth rate of the molluscan host and the shape of its shell is probably far more universal than is generally recognized. Kelly (1899) apparently first drew attention to this phenomenon in the United States when he recorded change of shell shape in Unionidae due to castration by *Bucephalus* cercariae. He writes:

> From the shape of the shells eight of these thirty-one individuals (infected with cercariae) were pronounced males and two females. Others, also belonging to species in which the shells of the two sexes are normally characteristic, had shells of such shape as to render the sex problematical and to suggest that infestation by *Bucephalus* or other cercariae, when early acquired and

long continued, may so alter the form of the shell of the female as to cause it to resemble that of the male or, if acquired later, may produce an intermediate form.

Rankin (1939) found slight abnormalities of the shell of *Pseudosuccinea columella* infected with echinostome cercariae, but "little or no effect on the snail host from infection with Xiphidiocercariae was observed."

The snails harboring *C. pricei* n. sp. were collected from a tiny isolated pond about 4 by 3 feet, the surface of which was entirely covered with vegetation. A certain number of relatively large specimens of *P. columella* were found resting on the upper side of waterlily leaves, exposed to direct sunshine even during the hottest period of the day (100° F. in the shade). All these proved to be infected with Xiphidiocercariae. No uninfected snails were found in this unprotected situation; there was thus a marked difference in the behavior of parasitized snails.

It is believed that all the mollusks[6] present in this pond were collected and examined. Only those that could have passed through a fine-mesh sieve might have escaped notice. The mean height of uninfected *P. columella* was 3 mm, the maximum size being 4 mm. Infected specimens reached 10 mm in height, with a mean of 9.75 mm. It is not suggested that parasitism is responsible for this great contrast in size, but it might well prove a contributing factor. Without a fairly prolonged study of the snail population of any given area it would be impossible to come to any definite conclusion on this point.

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[6] Four species, all of which were identified by Dr. J. P. E. Morrison, to whom I tender my best thanks.

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# PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

## THE ACADEMY

### 361ST MEETING OF THE BOARD OF MANAGERS

The 361st meeting of the Board of Managers was held at the Cosmos Club on Friday, May 24, 1940. There were 20 present as follows:

| | | |
|---|---|---|
| E. C. Crittenden | A. T. McPherson | E. W. Price |
| F. D. Rossini | A. Wetmore | R. R. Spencer |
| F. C. Kracek | C. Thom | C. L. Garner |
| H. S. Rappleye | W. A. Dayton | C. L. Gazin |
| J. H. Hibben | P. C. Whitney | W. W. Diehl |
| G. Steiner | H. L. Curtis | and by invitation |
| F. M. Setzler | W. Ramberg | J. H. Kempton |

Acting upon instructions from the Board, President Crittenden appointed the following committees:

(1) To consider societies qualified for affiliation with the Academy: F. M. Setzler, chairman; R. E. Gibson and R. R. Spencer, members.